Transport Canada Transports Canada

# Energy Research and Development Program

*Status Report*
*1988 / 89*

*September 1989*

Canada

# Introduction

The national transportation policy, as stated in the National Transportation Act, calls for the provision of a safe, economic, efficient and adequate network of services serving the needs of users to the general economic well-being of Canada. A more general government policy is to utilize science and technology fully to achieve national goals of economic progress.

A top priority of Transport Canada is to guard the public's safety in transportation, which encompasses safety against public health, as influenced by continuing advances in technological innovations.

Transport Canada's contribution to the Federal Government's Energy Research and Development program, administered by the multi-departmental Panel on Energy R&D (PERD), is directed at:

1) improving the energy efficiency and energy related environmental impact of all forms of transportation;

2) promoting the understanding of problems and opportunities posed by the introduction of new forms of energy in transportation;

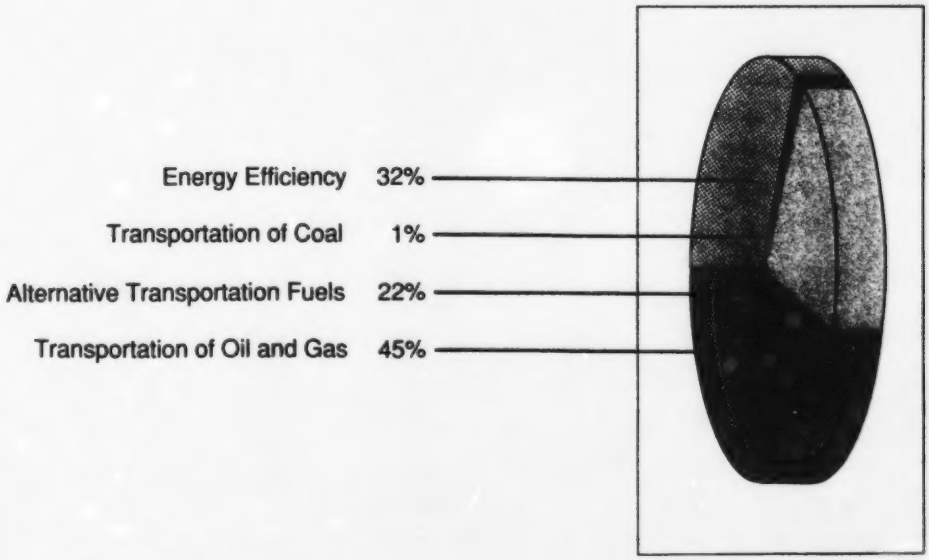
3) supporting the requirements for the transportation of energy commodities in frontier areas and in applications calling for advanced technologies.

This yearly report describes work performed during the fiscal year 1988-89. Projects in this document are funded under four specific programs. These include: the Energy Efficiency Program, the Transportation of Coal Program, the Alternative Transportation Fuels Program, and the Transportation of Oil and Gas Program. At the end of this report there is a listing of final project reports made available to the Energy R&D Program prior to the date of publication.

While these activities utilized some $4.7 million of PERD funding in 1988-89, they formed part of a $17 million multi-year R&D effort jointly funded by government and industry (Transport Canada A-base $5.2 million; PERD $9.3 million; industry $2.7 million) resulting in a leverage of 1.6:1 on PERD funding.

Anyone interested in particular detailed project information, or anyone who has questions concerning this publication should not hesitate to contact our offices. Inquiries should be directed to Mr. Marc Brenckmann, Director of Research Program Development, Transport Canada (613) 998-1817.

# Transport Canada's Energy R&D Program 1988 / 89 $4,677,699 *




* Operational and maintenance costs included in this figure.

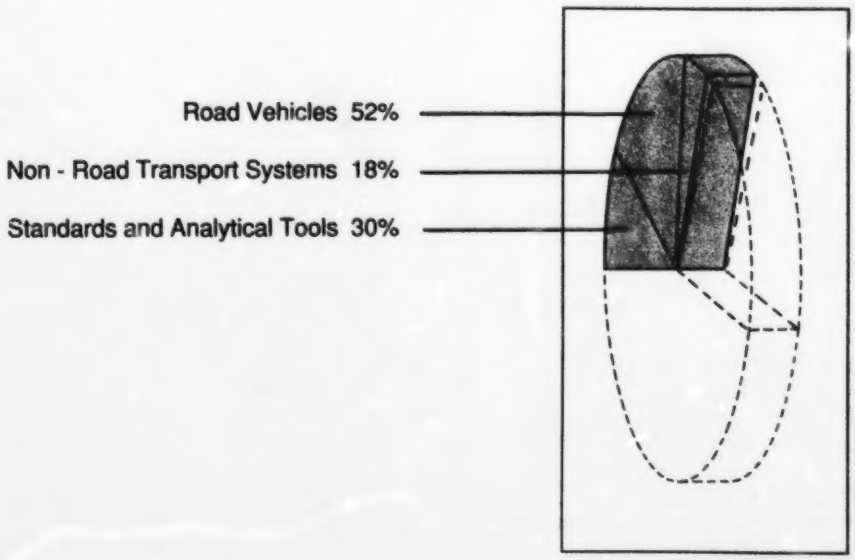
# Energy Efficiency R&D Program

## Highlights

Within this program, automotive and other transportation fuel consumption trends are monitored by Transport Canada as a basis for future needs, possibly related to guidelines about improving environmental impact and leading to standards setting. Mathematical predictive fuel consumption models, fuel efficiency testing, and validation methodologies continue to be subjects of work in support of this goal. A major concern for the Energy Efficiency Program is to reduce barriers to wider conservation initiatives. Also emphasized in the present program is the assessing of the cost-effectiveness of new technologies designed to improve vehicle fuel economy. Because the truck and bus sectors appear to offer the best opportunity for concerted action in the Canadian context, particular attention has been paid to them. Energy efficiency opportunities also exist in air, rail, and marine sectors. Selected generic technology development is being supported in these areas.

## PERD Expenditures 1988/89

## $1,482,648



# Task 1.5 Energy Efficiency
## Completed Projects

### STANDARDS AND ANALYTICAL TOOLS

### Fuel Efficiency Standards

- **Car Fleet Fuel Consumption** - This project resulted in the development of a fuel consumption model and computer program for estimating the total fuel consumption of the passenger car fleet in Canada. Road transport and energy planners and administrators require the capability to evaluate the effects on car fleet fuel consumption caused by differences in vehicle characteristics and usage, road traffic, operating and environmental conditions.

  Further research is needed into the effect of cold starts to eliminate the under-estimation of fuel consumption of approximately 10% by the program.

  **Current Yr. PERD Funding:** $30K
  **Total PERD Funding:** $30K
  **Total Project Cost**: $30K (07/88 - 03/89)
  **Contractor**: Bureau of Management Consulting
  **Report**: TP 9877E
  **Project Number**: 4082
  **Project Officer:** E. Welbourne (613) 998-1947

- **Instantaneous Road Load Estimation** - This project was designed to analyze the procedures for estimating the instantaneous road load (force needed to make a vehicle move) on passenger vehicles, to determine the reason(s) for the observed differences between the predicted and measured load values, and to propose appropriate changes to the instrumentation or the estimation procedure to correct these differences.

  The research had first to deal with failures in the Data Acquisition hardware, sampling rate and resolution limitations, and mechanical friction in the speedometer cable housing. A method was developed to reduce the magnitude of the unacceptably high fluctuations of velocity readings and resultant calculated road load without compromising transient response.

  **Current Yr. PERD Funding:** $16K
  **Total PERD Funding:** $16K
  **Total Project Cost**: $16K (04/88 - 03/89)
  **Contractor**: Davis Engineering Limited
  **Report:** "Validation of Procedures for Estimating Instantaneous Road Load"
  **Project Number**: 4078
  **Project Officer**: E. Welbourne (613) 998-1947

## Vehicle Fuel Consumption Analysis

- **Passenger Car and Light Duty Vehicle Survey** - The Fuel Consumption Survey has monitored energy conservation progress resulting in vehicle fuel consumption standards, vehicle labelling, and public information from 1979 to 1989. Survey results delineate that there has been a shift towards smaller, more fuel efficient cars, with an increased number having manual transmissions; that total distance travelled by larger cars has been decreasing while increasing for smaller cars, resulting in noticeable decline in fleet fuel consumption; that winter driving brings up to a 20% increase in fuel consumption for vehicles of all years; and that the population of light trucks and vans is increasing, with lighter, more fuel efficient vehicles representing a growing proportion of the fleet.

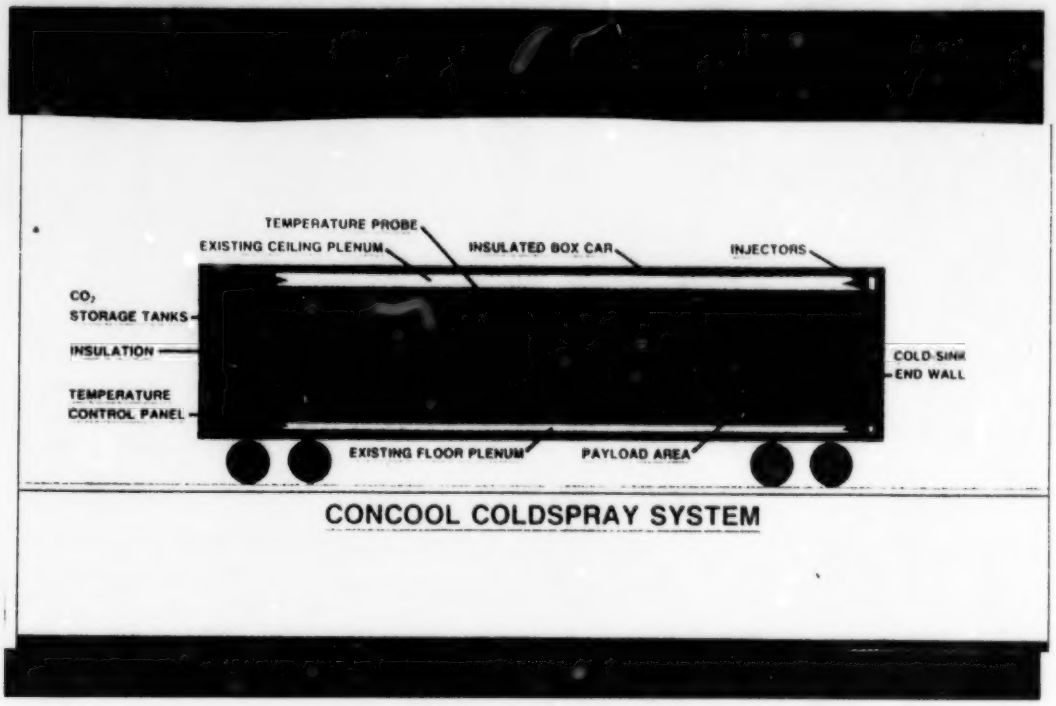
  **Current Yr. PERD Funding:** $395K
  **Total PERD Funding:** $395K
  **Total Project Cost**: $395K (04/88 - 03/89)
  **Contractor**: Statistics Canada
  **Report**: "The Fuel Consumption Data Book" is in progress.
  **Project Number**: 4016
  **Project Officer**: E. Lawrence (613) 998-1945

# ROAD VEHICLES

## Fuel Economy R&D

- **Heavy Vehicle Fuel Consumption** - This project was designed to investigate factors influencing the fuel consumption of heavy road vehicles. The cross impact between the drivers, the environment, the road, and the vehicles was analyzed and correlated. These effects were all studied in their actual commercial operations, and the results are useful in characterizing differences in fuel consumption depending on driver's techniques, truck-trailer combinations, road surfaces and road profiles. Ph. II - Heavy Vehicle Fuel Consumption Model will be discussed later in 1.5's Ongoing Projects.

  **Current Yr. PERD Funding:** $6K
  **Total PERD Funding:** $275K
  **Total Project Cost**: $280K (12/85-03/89)
  **Contractor**: Forest Engineering Research Institute
  **Report:** Report being reveiwed
  **Project Number**: 6593
  **Project Officer**: L. Sabounghi (514) 283-0029




*$CO_2$ Concool Coldspray System*

- **$CO_2$ Refrigeration** - Refrigerated transport usually relies on mechanical refrigeration. More reliable preservation of perishable products over long haul routes can be obtained using $CO_2$ refrigeration, based on the injection technique (coldspray) and the vaporization technique (coldsink). The "coldspray" injects $CO_2$ snow into the cargo area to maintain the required temperature. The "coldsink" injects into the cargo area $CO_2$ gas at varying pressures to attain the required temperature. The two techniques have been combined in a prototype 48-foot trailer equipped for fresh beef transport. Tests carried out demonstrated the superior performance of this type of equipment. $CO_2$ refrigeration is more energy efficient than mechanical refrigeration in that it uses abundant electricity rather than scarce fossil fuels.

**Current Yr. PERD Funding:** $56K
**Total PERD Funding:** $240K
**Total Project Cost:** $432K (11/85-09/89)
**Contractor:** Fridev-Concool
**Report:** TP 9778E
**Project Number:** 6495
**Project Officer:** L. Sabounghi (514) 283-0029

- **Nexus Project** - The purpose of this university-based exercise was to design, construct and evaluate a one-passenger commuter vehicle that would have low fuel consumption and still meet the Canadian Motor Vehicle Safety Standards (CMVSS). The Nexus vehicle was constructed and evaluated in 1986.

  This final phase of the project was concerned with vehicle resistance measurements. Current coastdown procedures have limitations in the wind-speed and road grades allowed as well as less acceptable results when the vehicle weighs less than 1000kg (Nexus weighs 600kg). A new data analysis procedure accounting for wind-speed and road-grade measurements was developed.

  Nexus was sold to the University of Saskatchewan and is on display at the National Museum of Sciences and Technology in Ottawa until February of 1990.

  **Current Yr. PERD Funding:** $35K
  **Total PERD Funding:** $39K
  **Total Project Cost**: $39K (10/87 - 03/89)
  **Contractor**: University of Saskatchewan
  **Report**: SAE Paper #800371
  **Project Number**: 4073
  **Project Officer**: D. Boucher (613) 998-1953

## Bus Technology

- **Regenerative Braking Power Train** - This project tested the emissions of a city bus to determine the connection between emission reductions and the use of a regenerative braking system. The city business district driving cycle (11 stops per km., 32 kms. per hour top speed) was used for emissions testing in actual driving conditions. This system was found to result in decreased environmental emissions, and fuel savings of up to 18%. The resulting emission reductions were: 19% for $NO_x$ emissions, 15% each for $CO_2$ and particulate emissions, 60% for CO emissions, and 8% for hydrocarbon emissions.

  **Current Yr. PERD Funding:** $12K
  **Total PERD Funding:** $50K
  **Total Project Cost**: $50K (04/87 - 06/88)
  **Contractor**: National Research Council
  **Report:** SAE Paper #890267
  **Project Number**: 0918
  **Project Officer**: T. Davies (613) 993-1272

## TRANSPORT SYSTEMS

### Intermodal

- **Lab Diesel Phase IV** - This project involves the development of a single-cylinder, four stroke medium-speed diesel engine test facility to carry out research and development on medium-speed diesel engines.

  Phase IV consisted of designing the Lube Oil Evaluation (LOE) version of the engine for research on the performance of lubricants; of developing the Turbocharger Test Rig (TTR) for improving turbocharger and overall engine performance and efficiency; of preparing an operational documentation package; and of adding an atomic absorption spectophotometer to the Fuels and Lubricants Laboratory for detection of wear metals in lubricating oil.

  **Current Yr. PERD Funding:** $100K
  **Total PERD Funding:** $300K
  **Total Project Cost**: $400K (06/87-06/89)
  **Contractor**: Bombardier Inc.
  **Report:** TP 9775E
  **Project Number**: 6798
  **Project Officer**: R. Nishizaki (514) 283-0026

*Front view of the turbocharger test cell*

# Task 1.5 Energy Efficiency
## Ongoing Projects

### ROAD VEHICLES

### Fuel Economy R&D

- **Monitoring Road Roughness** - Quantifying the effect of road surface roughness on the rolling resistance of truck tires is the continuing purpose of this project. The feasibility study of using the previously developed Truck Tire Rolling Resistance (TTRR) Measurement System to measure road roughness was confirmed at low frequencies of up to four Hertz. Higher frequencies led to motion between the trailer bed and the tag axle (safety device for the system), preventing correct inference of the road profile. Software to model the TTRR response was developed and debugged, and a locking mechanism for the tag axle is under development.

  **Projected Completion Date**: March 31, 1989
  **Current Yr. PERD Funding:** $101K
  **Forecasted Total PERD Funding:** $150K
  **Forecasted Total Project Cost:** $150K
  **Contractor**: Davis Engineering Limited
  **Report:** Phase I report available
  **Project Number**: 4078
  **Project Officer:** D. Boucher (613) 998-1953

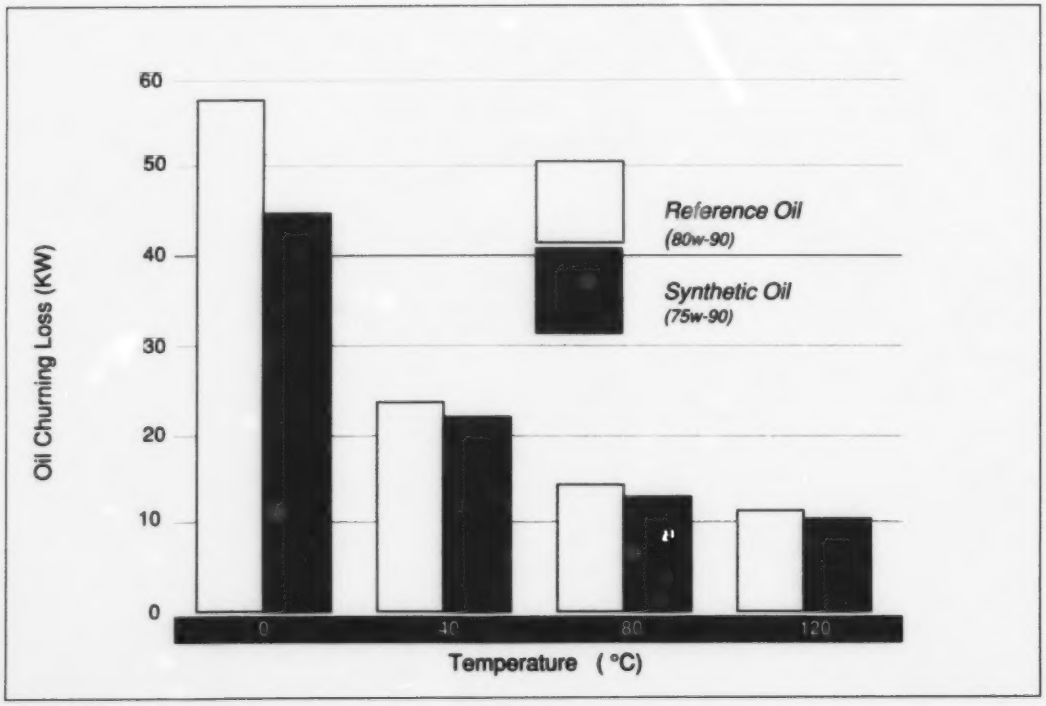
- **Exhaust-Charged Cycle** - The purpose of this project is to develop and evaluate the Exhaust Charged Cycle (ECC), which involves pressurizing the intake load with exhaust gases to improve engine fuel consumption during warm-up. In Phase II, the ECC was tested against a conventional cycle. The ECC engine performance during warm-up was considerably better, as was Brake Specific Fuel Consumption (BSFC). There was a substantial reduction in exhaust emissions during warm-up.

  Phase III is required for performing more optimization on the ECC and for performing preliminary work on converting a conventional 6-cylinder automobile engine to use the ECC.

  **Projected Completion Date**: March 31, 1993
  **Current Yr. PERD Funding:** $69K
  **Forecasted Total PERD Funding:** $186K
  **Forecasted Total Project Cost**: $186K
  **Contractor**: Thermotech Engineering
  **Report:** SAE Paper #890001
  **Project Number**: 4063
  **Project Officer**: D. Boucher (613) 998-1953

- **Heavy Vehicle Fuel Consumption Model** - This project is aimed at developing and calibrating an energy consumption model of heavy road vehicles, examining the relationship between driver, vehicle, road and environment in order to select the optimal vehicle-driver combination for each road transport task under certain conditions. The model will be tested in the forest industry and later released to the entire trucking industry, benefitting up to one-third of Canadian trucks. The model can be used as a tool to devise strategies leading to substantial reductions in fuel consumption also resulting in reductions in maintenance costs.

**Projected Completion Date**: April 30, 1992
**Current Yr. PERD Funding:** $78K
**Forecasted Total PERD Funding:** $530K
**Forecasted Total Project Cost**: $530K
**Contractor**: Forest Engineering Research Institute
**Report:** None to date
**Project Number**: 7131
**Project Officer**: L. Sabounghi (514) 283-0029




*Differential Oil Churning Power Loss at 80 km*

- **Truck Drive Train Tribology R&D** - Canadian trucks suffer power train transmission energy losses due to viscous churning, rubbing surface friction and lubricant traction. The objective of this project is to improve on existing oil capabilities and to select an optimal lubricant so as to reduce these energy losses. An optimized lubricant has been achieved in bench and axle rig tests and is currently undergoing full dynamometer and field testing. The lubricant performance must be achieved while taking into consideration the drive train durability.

  **Projected Completion Date:** March 31, 1990
  **Current Yr. PERD Funding:** $100K
  **Forecasted Total PERD Funding:** $250K
  **Forecasted Total Project Cost**: $450K
  **Contractor**: Imperial Oil
  **Report:** None to date
  **Project Number**: 6884
  **Project Officer**: L. Sabounghi (514) 283-0029

## Bus Technology

- **Ker-Train Bus Installation** - Ker-Train Systems Limited are developing an Incrementally Variable Transmission (IVT) under contract with the Department of National Defence (DND). The IVT is being built for use in an armoured personnel carrier, with engine specifications similar to those of urban buses.

  The scope of this Transportation Development Centre (TDC) project is to access this work and manufacture an IVT transmission for installation in an urban bus, which could provide fuel savings of up to 30%. The design is virtually complete using results from the work underway for DND. All key components are ready for assembly in December of 1989. The demonstration prototype will introduce the IVT to a commercial market which would otherwise have been unable to support the full-scale development cost.

  **Projected Completion Date**: March 31, 1990
  **Current Yr. PERD Funding:** $93K
  **Forecasted Total PERD Funding:** $200K
  **Forecasted Total Project Cost**: $288K
  **Contractor**: Ker-Train Systems Limited
  **Report:** None to date
  **Project Number**: 6872
  **Project Officer**: J. Morgan (514) 283-0032

## Urban and Regional

- **Integrated Traffic System** - This project is aimed at developing a micro-computer based integrated traffic control system to provide efficient traffic regulation, improved service and safety, increased capacity, and reduced maintenance cost and vehicle energy consumption. It is being structured so that additional programs may be incorporated into the basic system.

  Implementation will commence in July of 1989 within three Ontario municipalities; Ottawa-Carleton, Toronto, and the Regional Municipality of Durham. Assessment will follow, outlining possible improvements and highlighting benefits.

  **Projected Completion Date**: December 31, 1989
  **Current Yr. PERD Funding:** $52K
  **Forecasted Total PERD Funding:** $161K
  **Forecasted Total Project Cost**: $439K
  **Contractor**: IBI Group
  **Report:** None to date
  **Project Number**: 6820
  **Project Officer**: J. Morgan (514) 283-0032

*Municipal traffic control system, a necessity*

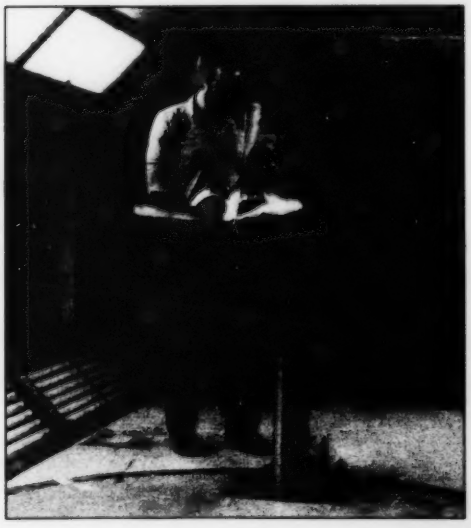
## TRANSPORT SYSTEMS

### Air Transportation

- **Computational Aerodynamics** - Pratt and Whitney (P&WC) and DeHavilland (DHC) have been involved in a joint research and development program seeking improvements in aircraft fuel efficiency, using the VSAERO computer code and wind tunnel testing. The success of this program has led to more analysis, testing and design of propellers, engine air intakes and complete nacelles.

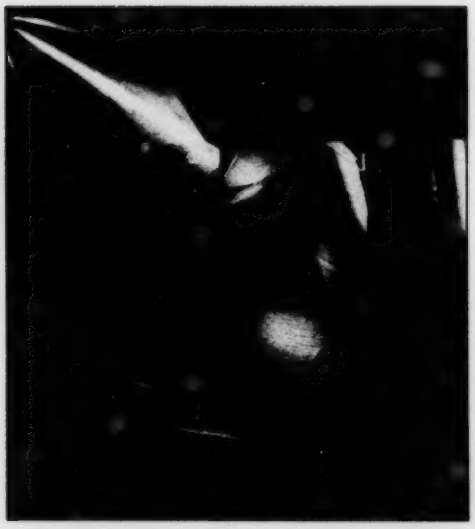
  The objectives of this project are; to provide a means for reducing nacelle drag, to improve the propeller blade cuff design, and to investigate the aerodynamics of a pusher propeller installation. P&WC and DHC will have greater knowledge of the airflow through and around nacelles, and will be able to design more optimal propeller/nacelle configurations leading to increases in fuel savings.

  **Projected Completion Date**: October 31, 1990
  **Current Yr. PERD Funding:** $86K
  **Forecasted Total PERD Funding:** $400K
  **Forecasted Total Project Cost**: $400K
  **Contractor**: Pratt & Whitney Canada Inc., Boeing Canada Ltd. - DeHavilland Division
  **Report:** None to date
  **Project Number**: 7057/7058
  **Project Officer**: A. Versailles (514) 283-0024

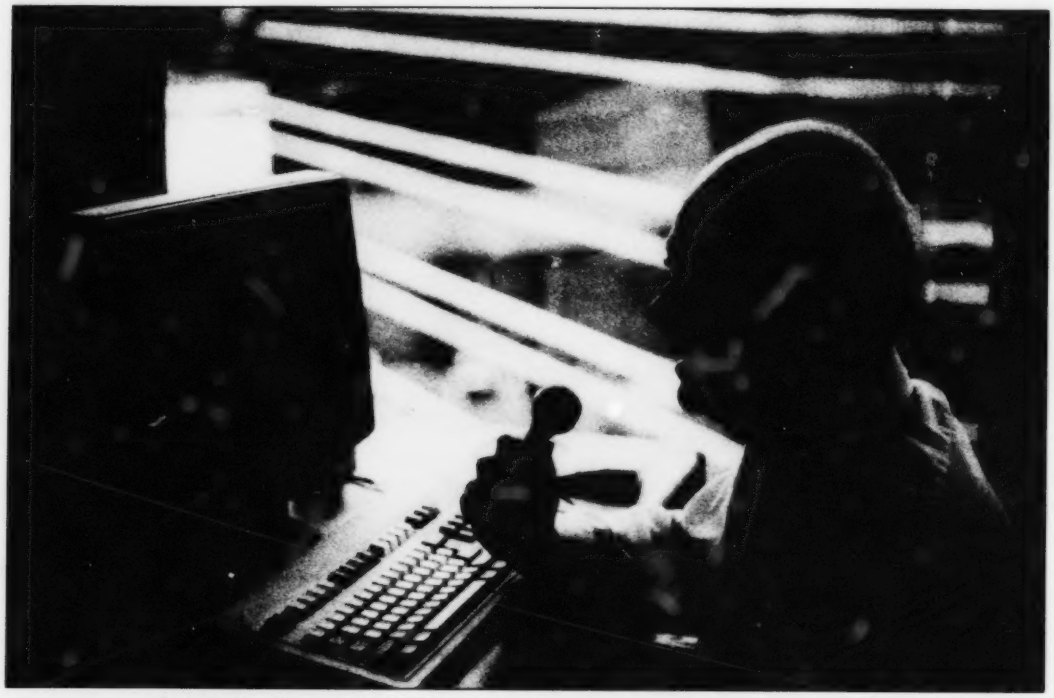


*Model configuration in wind tunnel*

*Flow visualisations on typical nacelle configuration*



## Intermodal



*Knowledge-based dispatching aid with voice synthesis and recognition*

- **Knowledge-Based Dispatcher** - The transportation of dangerous goods relies on experienced dispatchers monitoring many changing variables. This project developed a vehicles dispatcher's aid using a knowledge base, combined with other software and programs linking to the main system Database. The system will free dispatchers from time-consuming, lower-level decisions, thus achieving greater efficiency and cost-effectiveness. The prototype was successfully tested and reviewed. The system is further enhanced with voice synthesis and recognition.

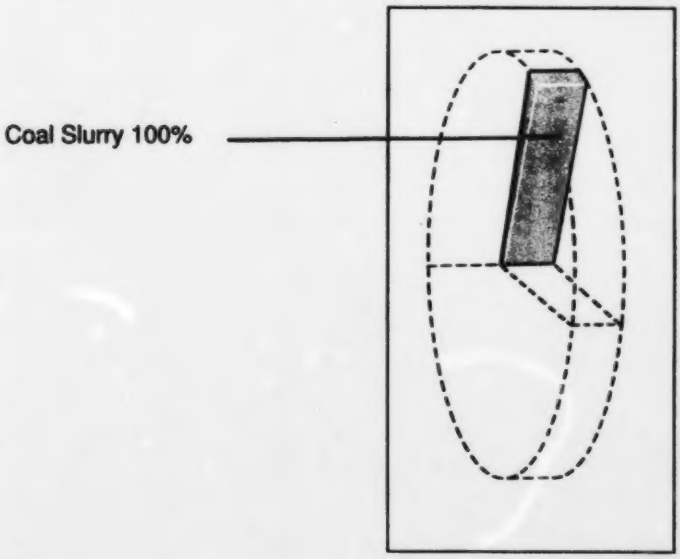
**Projected Completion Date:** December 31, 1989
**Current Yr. PERD Funding:** $69K
**Forecasted Total PERD Funding:** $100K
**Forecasted Total Project Cost**: $156K
**Contractor**: Applied AI Systems Inc.
**Report:** None to date
**Project Number**: 6901
**Project Officer**: L. Sabounghi (514) 283-0029

# Transportation of Coal R&D Program
## Highlights

The participation of Transport Canada in the Coal Transport Program is generally concerned with lowering the transportation cost of coal through technological innovation. This can be achieved through the improvement of existing transport modes as well as by innovative transportation means. A state-of-the-art review of the transportation of coal by specialized unit trains completed during the previous year has singled out several specific R&D areas, some of which have been initiated this year.

## PERD Expenditures 1988/89

## $57,467



# Task 2.1 Transportation of Coal
## Ongoing Projects

- **TIES Rail Freight R&D** - This study addressed the problems currently encountered in the rail transportation of coal. Current state-of-the-art technology has been reviewed with the aim of identifying potential improvements regarding safety, efficiency and effectiveness.

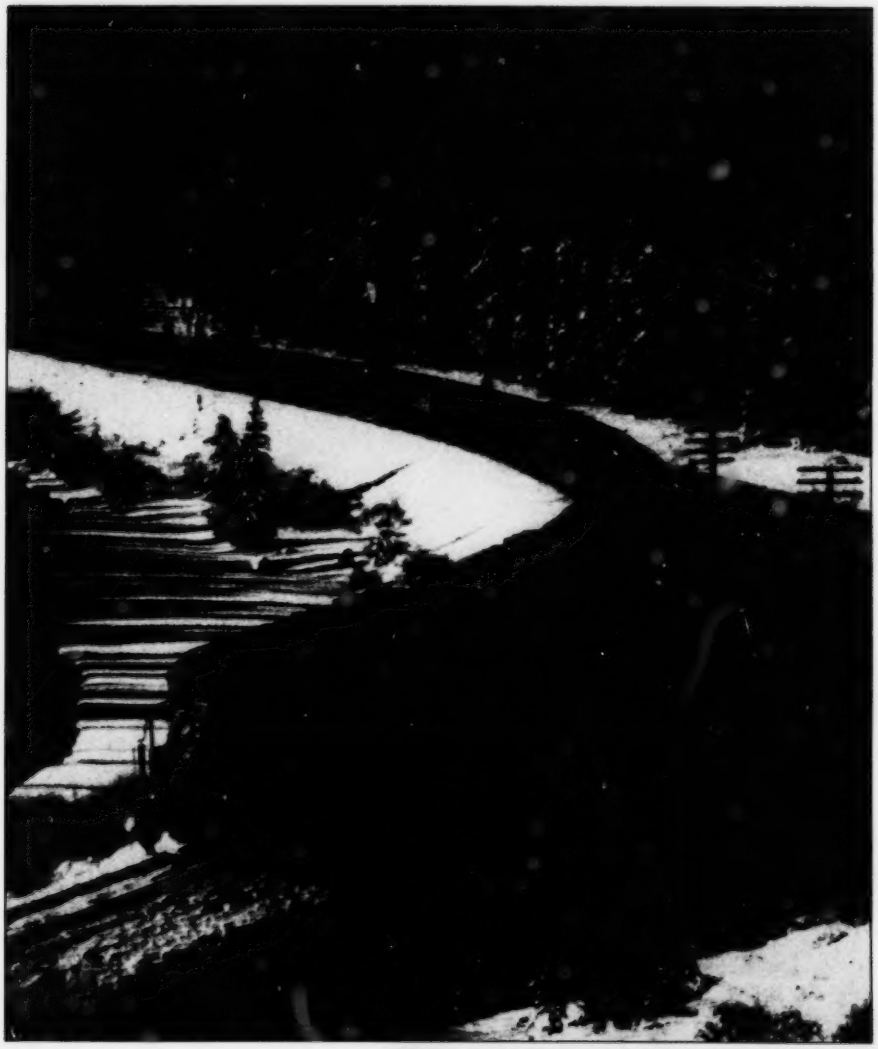
  Ongoing technological developments and research of pertinent areas have been summarized in report format. Data has been collected on the following: radial axle trucks, reduction in freight car weight, reduction of train resistance, AC traction, rail profile grinding, concrete track tires, rear-of-train telemetary, locomotive event recorders, and advanced train control systems.

  The report, entitled "Rail Transportation of Coal in Western Canada" (May 1988), is available on request.

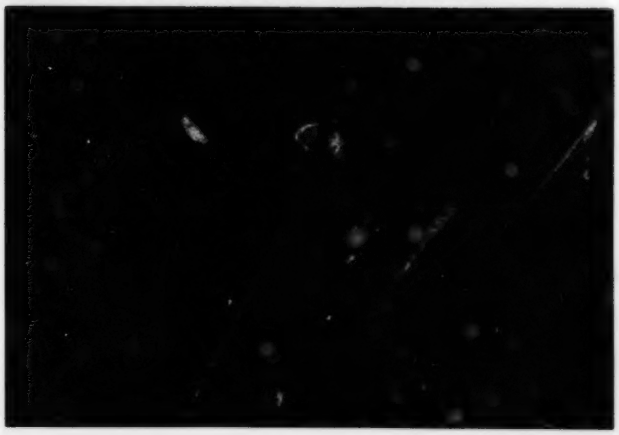
  **Projected Completion Date**: March 31, 1990
  **Current Yr. PERD Funding:** $10K
  **Forecasted Total PERD Funding:** $50K
  **Forecasted Total Project Cost**: $50K
  **Contractor**: Maughan Rail Consulting Services
  **Report:** Task 2 - TP 9316E
  **Project Number**: 6975
  **Project Officer**: B. McLaren (514) 283-0006

- **Radial Truck Test Program** - Unit coal trains equipped with conventional three-piece trucks suffer from lateral instability, curving difficulties and maintenance problems. These performance limitations lead to increased fuel consumption and wheel and rail wear, damage and deterioration to both track and equipment, and effectively lowers the maximum speed attainable by lightly loaded or empty cars. This project is concerned with comparing fuel consumption, wheel and component wear, and high-speed stability performance of conventional trucks with Barber radial and DR-2 radial trucks. There will also be an evaluation of the wheel wear performance of the UTDC frame-braced truck in standard unit train coal service.

  **Projected Completion Date**: December 29, 1989
  **Current Yr. PERD Funding:** $48K
  **Forecasted Total PERD Funding:** $81K
  **Forecasted Total Project Cost**: $81K
  **Contractor**: CP Rail
  **Report:** None to date
  **Project Number**: 7185
  **Project Officer**: D. Dibble (514) 283-0066



*Coal train in Western Canada*



*DR-2 Self-steering Truck*

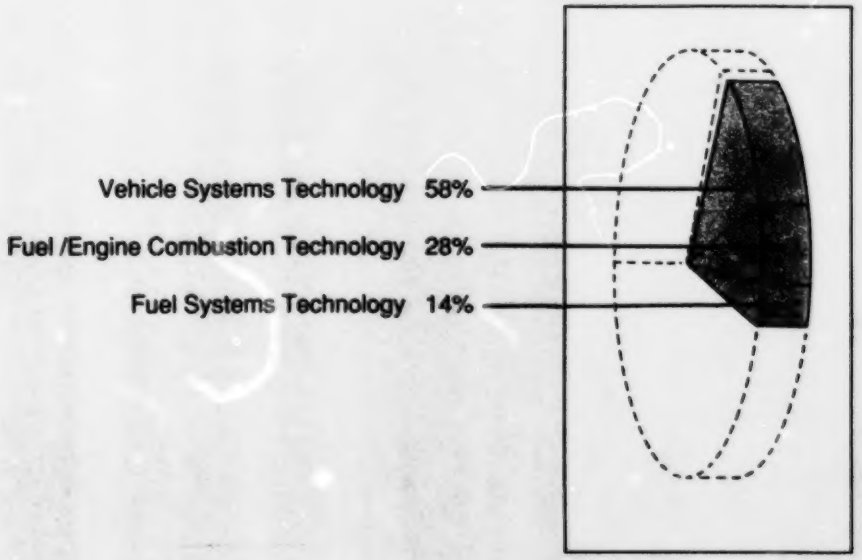
# Alternative Transportation Fuels R&D Program
## Highlights

Transport Canada's primary objectives in alternative transportation fuel use R&D are aimed at ensuring a safe, orderly, and environmentally acceptable introduction of alternative fuels into the transportation sector. Toward this end, it is the responsibility of the department to develop or encourage the development of a sound technical and regulatory basis for using, transporting, handling and distributing new fuels.

The particular areas where these goals were pursued, in conjunction with efforts by other departments, comprised the health, safety and environmental impact of the use of methanol in automotive vehicles; the development of test facilities for engines and vehicles using alternative fuels and advanced battery technology is of interest to the transportation sector.

## PERD Expenditures 1988/89

## $1,053,989



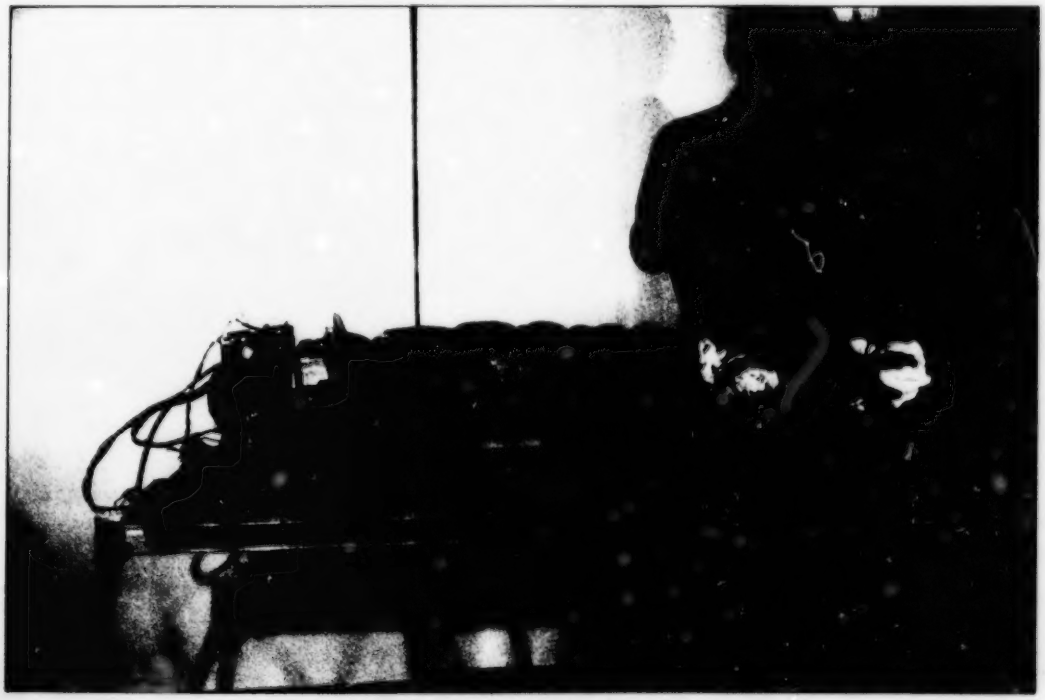
# Task 5.5 Alternative Transportation Fuels
## Completed Projects

### VEHICLE SYSTEMS TECHNOLOGY

### Vehicle Safety and Alternative Fuels Technology

- **Safety of Alcohol-Fuelled Road Vehicles (Phase II)**- This project was concerned with the safety aspects of methanol fuel in three areas; flame visibility, fuel ignition on hot manifolds, and flammable vapours in the fuel tank. Eight fuels were investigated, including 100% methanol, 100% gasoline, and methanol with a cetane improver. Fuels were burned on different surfaces, and methanol fuels varied between moderately visible and virtually invisible. Leakage of methanol fuels onto a hot manifold might increase the risk of engine compartment fires. Installation of a diode across the pump terminal proved to be successful in preventing fuel vapour ignition.

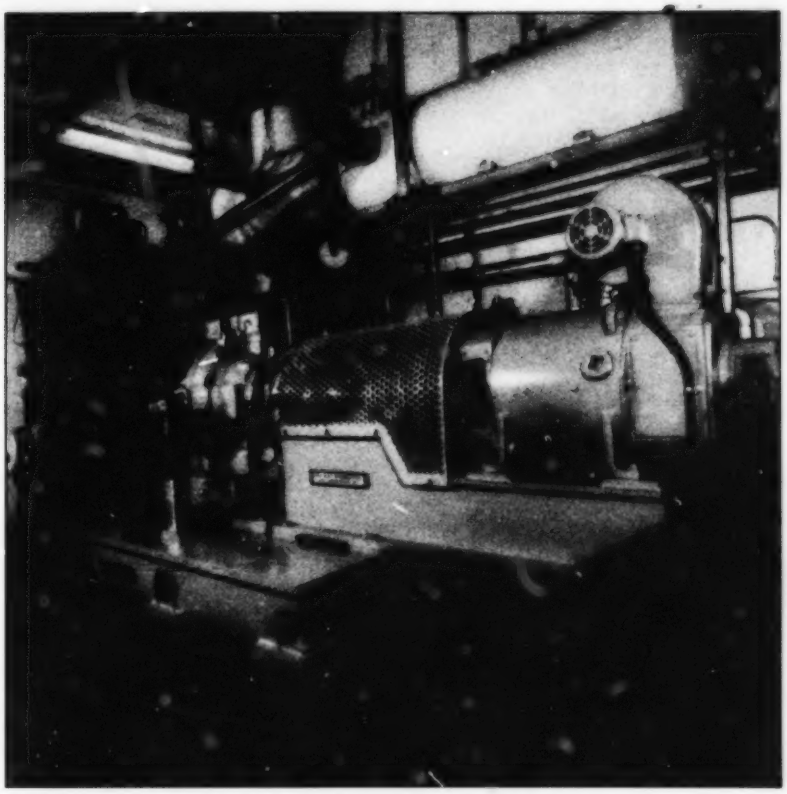
  **Current Yr. PERD Funding:** $112K
  **Total PERD Funding:** $153K
  **Total Project Cost**: $153K (03/87-03/89)
  **Contractor**: Ontario Research Foundation
  **Report:** In progress
  **Project Number**: 4032
  **Project Officer**: V. Battista (613) 998-1950



*Testing of alcohol fuels for flammability*

## FUEL/ENGINE COMBUSTION TECHNOLOGY

### Operations/Technology Assessment



*Newly installed motoring dynamometer*

- **SCRE Test Facility Upgrade** - The National Research Council's Single Cylinder Research Test Facility is used to conduct research on medium-speed diesel performance with various fuels or for varying component design parameters. In order to provide a full range of operating conditions, two major changes were implemented: the existing dynamometer was replaced with a substantially lower rotational inertia motoring system, and a feature was incorporated to enable the decoupling of the dynamometer. The improved facility will continue to be used for combustion research and for the testing of components incorporating advanced technology features tailored to alternative fuels.

**Current Yr. PERD Funding:** $0*
**Total PERD Funding:** $200K
**Total Project Cost**: $200K (01/88 - 06/88)
**Contractor**: National Research Council
**Report:** TP 9871E
**Project Number**: 7029
**Project Officer**: R. Nishizaki (514) 283-0026

* For completeness; follow-up on project not funded in this fiscal yr.

- **Heavy Duty Engines (TIES #2)** - A study was carried out to determine the need for heavy duty engine emissons testing in Canada focusing on heavy duty diesels and also to evaluate existing North American emissions test facilities. Emissions testing involves compliance monitoring and research work. Compliance monitoring requires an engine dynamometer and prescribed regulated tests. Research can be performed on an engine of chassis dynamometer, but existing chassis dynamometer facilities lack the complete range of hardware to perform extensive emissions tests on heavy duty vehicles.

  This study recommended that a facility be established with a chassis dynamometer and the necessary emissions testing equipment, providing researchers with the means to study the emissions of heavy duty vehicles and determine necessary emission regulations.

  **Current Yr. PERD Funding:** $9K
  **Total PERD Funding:** $9K
  **Total Project Cost**: $80K (03/88 - 10/88)
  **Contractor**: Sypher:Mueller International
  **Report:** Draft report available
  **Project Number**: 0834
  **Project Officer**: M. Ball (613) 991-6027

## FUEL SYSTEMS TECHNOLOGY

### Storage/Handling/Distribution

- **Storage and Distribution of Methanol Fuels** - A study has been made to compare the safety of high-methanol content fuels with conventional fuels while being transported by marine, rail, truck, and pipeline modes. Data was collected regarding storage, transportation, and distribution of neat methanol fuels. The study concluded that methanol fuels would not likely increase the level of casualities and fire damage now experienced with gasoline; the casualty level may actually be reduced at service stations. Because methanol fuels burn with a low radiant heat emmission, the area in which damage occurs will be reduced. This advantage may be offset by the somewhat greater frequency of methanol spills due to increased volume requirements of methanol fuelled vehicles compared to gasoline fuelled vehicles. The risk of toxicity from methanol distribution (compared to gasoline) is not expected to increase in industry employees. It has been recommended that further risk analyses work be undertaken.

  **Current Yr. PERD Funding:** $46K
  **Total PERD Funding:** $64K
  **Total Project Cost**: $64K (12/87 - 08/88)
  **Contractor**: R.F. Webb Corporation
  **Report**: TP 9519E
  **Project Number:** 0836
  **Project Officer**: M. Ball (613) 991-6027

# Task 5.5 Alternative Transportation Fuels
## Ongoing Projects

### VEHICLE SYSTEMS TECHNOLOGY

### Vehicle Safety and Alternative Fuels Technology

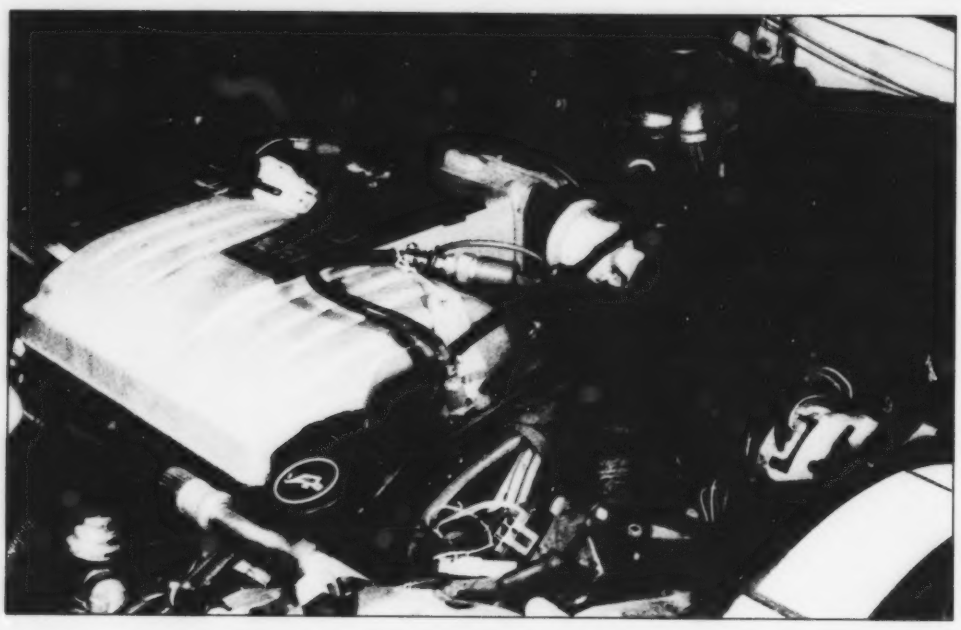
- **Cold Start Data Analysis** - Cold starting of methanol engines is significantly poorer than that of gasoline engines, attributable to factors such as fuel characteristics and engine configurations.

  The objectives of this project are to gather cold start data from various Canadian and foreign sources, to prepare a database, and to analyze and summarize the data. A quantitative analysis of the data will use the cold starting model and previously developed multi-component fuel volatility models.

  **Projected Completion Date**: September 15, 1989
  **Current Yr. PERD Funding:** $27K
  **Forecasted Total PERD Funding:** $35K
  **Forecasted Total Project Cost**: $51K
  **Contractor**: Thermotech Engineering
  **Report**: None to date
  **Project Number**: 4077
  **Project Officer**: V. Battista (613) 998-1950

- **Exhaust-Charged Cycle for Methanol Engine** - The objective of this project is to improve the cold starting of methanol-fuelled engines through the use of the Exhaust Charged Cycle (ECC). Additional work under this contract consisted of conducting volatility and flammability verification assessments on several methanol/gasoline fuel blends. Modifications to the ECC test apparatus were initiated. After further testing using the camshaft designed for gasoline, a methanol test camshaft will be designed, constructed and installed for testing.

  **Projected Completion Date**: December 31, 1989
  **Current Yr. PERD Funding:** $19K
  **Forecasted Total PERD Funding:** $51K
  **Forecasted Total Project Cost**: $51K
  **Contractor**: Thermotech Engineering
  **Report**: None to date
  **Project Number**: 4081
  **Project Officer**: V. Battista (613) 998-1950



*Testing of flexible fuelled vehicle*

- **Flexible-Fuelled Vehicle Evaluation** - The objective of this project is to study the cold starting capability of various methanol/gasoline blends in a flexible-fuelled vehicle, in preparation for further emission testing.

  Tests have been completed on M85 (3 RVPs), M70, M25 and gasoline. Satisfactory starts have been obtained on all fuels except gasoline down to -30°C. Repeats tests are being planned for gasoline with a new computer chip and different injectors. Tests are also planned for evaluating M100 and M90 using an isocrackate fuel.

  **Projected Completion Date**: August 31, 1989
  **Current Yr. PERD Funding:** $26K
  **Forecasted Total PERD Funding:** $26K
  **Forecasted Total Project Cost**: $26K
  **Contractor**: National Research Council
  **Report:** Draft report available
  **Project Number**: 4072
  **Project Officer**: V. Battista (613) 998-1950

*Field ice testing along the Eastern Access to the Beaufort Sea*

- **Beaufort Sea Accessibility Study** - Phase I of this project investigating the environmental limitations to deep-draft shipping operations along the Southern Route of the North-West Passage is now complete. Three years of winter synthetic aperture radar (SAR) data over the consolidated waterways of the Southern Route (1986-89) was collected and analyzed. The conclusions highlight the potential feasibility of year-round trafficability of deep-draft tankers along the Southern Route. More detailed work in this area (Phase II) will commence in 1989-90.

  **Projected Completion Date:** March 31, 1990
  **Current Yr. PERD Funding:** $280K
  **Forecasted Total PERD Funding:** $350K
  **Forecasted Total Project Cost**: $350K
  **Contractor**: Canarctic Shipping Limited
  **Report:** TP 9906E
  **Project Number**: 1106
  **Project Officer**: W. Ellwood (613) 990-3087

- **Neat Methanol-Fuelled Vehicles Evaluation** - Methanol is an attractive alternative to gasoline and diesel as a transportation fuel, but it causes concern in that it produces significantly higher levels of aldehyde than gasoline produces (especially at low temperatures). The objectives of this project are to determine the dependence of emissions on ambient temperatures and accumulated distance, and to monitor reportedly higher engine wear in spark ignition methanol-fuelled, light-duty vehicles. Emission test results show the highest formaldehyde emissions with methanol-fuelled vehicles, while these vehicles produce lower HC, CO and $NO_x$ emissions. Methanol fuel injected vehicles have lower energy consumption and showed less temperature effects than carburetted vehicles. Used oil analyses indicated that wear rates in properly lubricated methanol engines are similar to those in gasoline engines.

  **Projected Completion Date**: May 31, 1989
  **Current Yr. PERD Funding:** $232K
  **Forecasted Total PERD Funding:** $493K
  **Forecasted Total Project Cost**: $493K
  **Contractor**: Ortech, Esso Petroleum
  **Report**: None to date
  **Project Number**: 4022
  **Project Officer**: V. Battista (613) 998-1950

- **Cold Start Development of Methanol Vehicles** - The objective of this project is to improve the low temperature starting capability of methanol-fuelled, light-duty vehicles. A Porsche test vehicle is being utilized with 90% and 100% pure methanol.

  More powerful batteries and starters effectively lower the cold starting temperature. The optimization of fuel injection, with a delayed injection and different quantity, lowers further the cold starting temperature. Intake air and fuel preheating have little effect on cold starting improvement, while heating up the combustion chamber walls seems to be more effective. Further measures are required to improve the low temperature starting capability of an engine operating on 100% methanol.

  **Projected Completion Date**: September 30, 1989
  **Current Yr. PERD Funding:** $195K
  **Forecasted Total PERD Funding:** $339K
  **Forecasted Total Project Cost**: $339K
  **Contractor**: Porsche AG
  **Report:** Draft report available
  **Project Number**: 4061
  **Project Officer**: V. Battista (613) 998-1950

## FUEL/ENGINE COMBUSTION TECHNOLOGY

### Operations/Technology Assessment

- **Heavy Duty Engines/Alternative Fuels Testing Facility** - A number of current developments point to the need for a Canadian testing facility capable of emissions testing of heavy duty vehicles in simulated operating conditions. The Environment Canada (EC) Vehicle Emissions Testing Laboratory (VETL) has previously been used both by EC and Transport Canada to test the emissions of light duty vehicles.

  This project is concerned with upgrading the VETL. The equipment being upgraded includes: a chassis dynamometer, a sampling system and an automation system. The chassis dynamometer will be capable of testing heavy-duty single axle trucks and urban buses. A system controller and software diagnostics package, yet to be added, will complete the enhancement. The capacity of the emissions sampling system was increased with a secondary tunnel and additional blowers. An automation system was provided for analysis instrumentation. The upgraded VETL will allow for research work and emissions testing of heavy duty vehicles, also the new cell will accomodate testing in ambient cold weather conditions.

  **Projected Completion Date**: Nov. 30, 1989
  **Current Yr. PERD Funding:** $250K
  **Forecasted Total PERD Funding:** $670K
  **Forecasted Total Project Cost**: $670K
  **Contractor**: Environment Canada
  **Report**: Interim report available
  **Project Number**: 1033
  **Project Officer**: C. Wachmann (613) 953-1134

## FUEL SYSTEMS TECHNOLOGY

### Fuel Storage/Handling/Distribution

- **AE Testing of NGV Cylinders** - This project is designed to develop Accoustic Emission (AE) techniques as an alternative to hydrostatic retesting of the fuel tanks of natural gas powered vehicles (NGV). The materials currently used in NGV cylinders will be tested for fracturability and vulnerability, providing a technical basis for AE testing methods. Laboratory testing, as well as that done at the cylinder retesting station, will provide the results from which a correlation between AE and hydrostatic testing will be established. A feasibility determination of AE procedures for recertifying NGV fuel cylinders will follow.

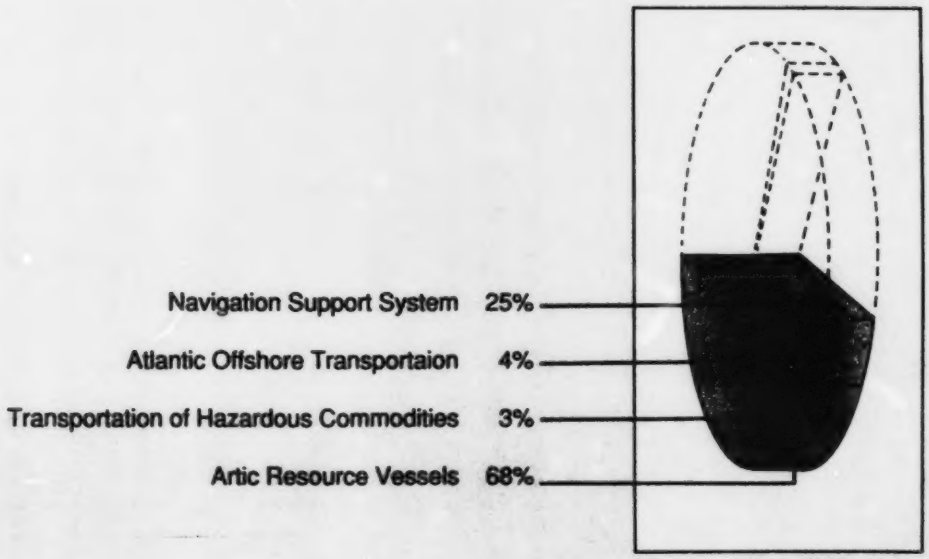
  **Projected Completion Date**: March 31, 1990
  **Current Yr. PERD Funding:** $100K
  **Forecasted Total PERD Funding:** $225K
  **Forecasted Total Project Cost**: $225K
  **Contractor**: Canadian Gas Association
  **Report**: None to date
  **Project Number**: 7211
  **Project Officer**: D. Dibble (514) 283-0066

# Transportation of Oil and Gas R&D Program
## Highlights

Transport Canada strives to facilitate the introduction of new technology for the safe, reliable, and economically viable transportation of oil and gas from their points of production (particularly in frontier regions) to their users. Transport Canada is also undertaking work to improve and develop transportation services which support oil and gas exploration, production, and extraction operations. To a large degree, this program has concentrated on the marine transportation problems occurring in the Arctic and along the East Coast. A smaller component deals with surface tanker vehicle safety.

## PERD Expenditures 1988/89

## $2,083,565


Navigation Support System 25%
Atlantic Offshore Transportaion 4%
Transportation of Hazardous Commodities 3%
Artic Resource Vessels 68%

# Task 6.6 Transportation of Oil and Gas
## Completed Projects

### NAVIGATION SUPPORT SYSTEMS

### Ice Detection

- **Sonar Retractable Transducer** - Based on previous testing, it is known that the sonar transducer can detect ice hazards up to four kilometres of the ship's hull. The objectives of this project were to modify the original prototype so as to develop a proximity sensing system for the transducer and to design a mechanism to withdraw the transducer quickly from the water when potentially damaging ice approached. The modified full system will be tested in the Arctic for this "Seek and Hide" approach of detecting and then avoiding ice hazards.

  **Current Yr. PERD Funding:** $100K
  **Total PERD Funding:** $100K
  **Total Project Cost**: $490K (07/88-10/89)
  **Contractor**: C-Tech Limited
  **Report:** In progress
  **Project Number**: 6970
  **Project Officer**: M. Audette (514) 283-0044

### Navigation Information Display

- **Marine-Vue and Nav-Ice Integration** - Marine-Vue displays real-time and processed radar images relayed from marine radar systems. Previous testing of the prototype NAV-ICE system aboard the M.V. Arctic and recent developments in digital processing indicated several possible improvements to the electronic displays, which were tested in this project.

  This project led to technical upgrades to hardware and software. New features were added: a cursor providing range and bearing for operator-selected targets, a radar video processor for presentation control, and components integrating the returns from a dual-polarization radar antenna. Upgrades for the radar interconnecting to the NAV-ICE system were implemented and the system was tested at sea.

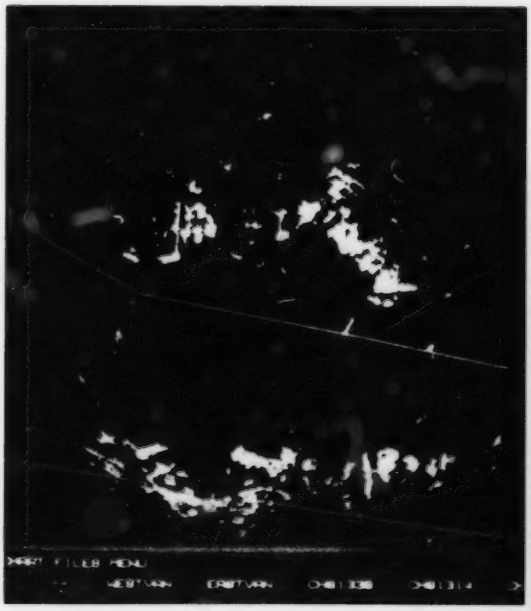
  **Current Yr. PERD Funding:** $72K
  **Total PERD Funding:** $150K
  **Total Project Cost**: $220K (09/87-10/88)
  **Contractor**: Intera Technology Limited
  **Report:** In progress
  **Project Number**: 6961
  **Project Officer**: M. Audette (514) 283-0044

- **SINADS Marine Navigation System** - This project was designed to meet the need in the marine industry for a standard bridge display console which can integrate all of a ship's navigational and radar data. The development of SINADS (Shipboard Integrated Navigation and Display System) provides a real-time graphic representation and track history of a ship's location and movements, as well as target tracking and collision avoidance warning.

  The hardware and software design led to the assembly of an initial prototype. Testing of the finished system aboard a Canadian Coast Guard (CCG) vessel at sea was successful and productive. Further modifications to the prototype were incorporated into the concept.

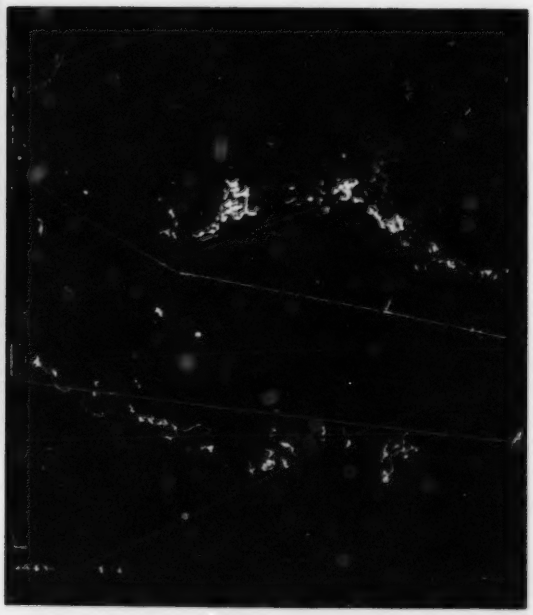
  As a result of this project, SINADS is now a flexible, expandable and marketable system providing navigational assistance in confined waters. Channel and coastal ferry operators, as well as the CCG, are potential beneficiaries of SINADS.

  **Current Yr. PERD Funding:** $80K
  **Total PERD Funding:** $200K
  **Total Project Cost**: $778K (10/86-05/89)
  **Contractor**: Offshore Systems Limited
  **Report:** TP 9696E
  **Project Number**: 6739
  **Project Officer**: H. Posluns (514) 283-0034



*Radar image with route graphics*

*Electronic chart with edge enhanced radar image*



- **Feasibility Helicopter SAR** - The ability to identify the best active radar imaging system for helicopter applications is a major concern of the Canadian Coast Guard (CCG). This project was designed to assess which equipment should be used for a ship with helicopter ice reconnaissance capability. Helicopter simulations, using real radar data, correlated information on the imaging characteristics of SAR, SLAR, and Search Radar. The effect on image quality of radar type, antenna length, altitude and frequency was investigated. The CCG will use this information and sensor performance results to decide on the best sensor technology available.

  **Current Yr. PERD Funding:** $27K
  **Total PERD Funding:** $70K
  **Total Project Cost**: $100K (10/88-09/89)
  **Contractor**: Intera Technology Limited
  **Report:** In progress
  **Project Number**: 7171
  **Project Officer**: M. Audette (514) 283-0044

## ATLANTIC OFFSHORE TRANSPORTATION

### Offshore Resource Vessel Requirements

- **Specifications for Thyssen-Waas Bow** - Over the past several years, Transport Canada has been involved in the systematic investigation of both conventional and unconventional types of icebreaking bow forms. Recently, attention has been directed to the Thyssen-Waas Bow configuration which was originally tested on the retrofitted West German icebreaker, the Max Waldeck, and later on the Russian icebreaker, the Mudyug.

  This study covers the development of specifications for a Thyssen-Waas Bow section for the integration with hulls of ice-classed vessels from Canadian applications. Preliminary examinations have been executed on three types of Canadian vessels: a RO-RO (roll-on, roll-off) ferry, product tanker, and ice management/container vessel. The preparation of specifications was completed. Commercial activities have delayed the completion of the report.

  **Current Yr. PERD Funding:** $17K
  **Total PERD Funding:** $163K
  **Total Project Cost**: $163K (01/84 - 04/89)
  **Contractor**: Marytown Shipyard Limited
  **Report:** Final draft received
  **Project Number**: 6026
  **Project Officer**: R. Nishizaki (514) 283-0026

## ARCTIC RESOURCE VESSELS

### Arctic Propulsion Systems

- **Propulsion Dynamics Math Model** - Full-scale tests of icebreaker propulsion systems have gathered data on propulsion train response to ice interaction over the past few years. This work aided in the development of numerical models for designing and evaluating ice class shafting and propeller systems. These models can be used for evaluating existing design methodology, regulations, vessel aspects and propulsion system operational aspects.

  The objective of this project was to develop a software package to access the data and execute these numerical models. This system was written for IBM PC/AT compatibles, is applicable to any ship or class, and is used for the analysis and design of static and dynamic shafting and propeller system characteristics in torsion, thrust and alignment.

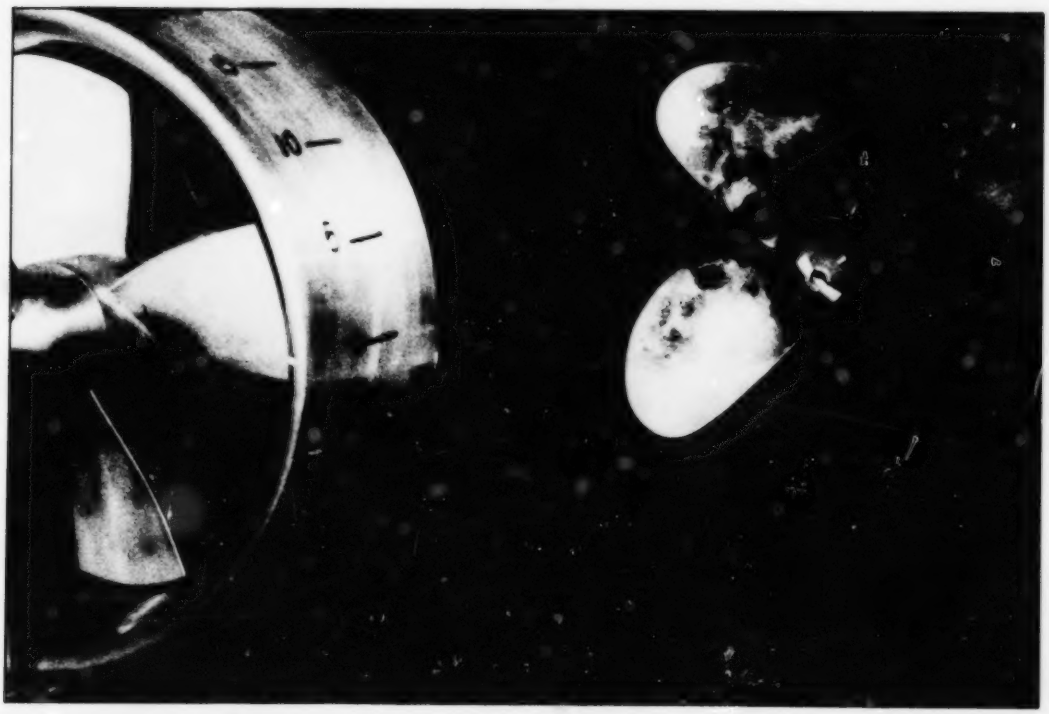
  **Current Yr. PERD Funding:** $50K
  **Total PERD Funding:** $100K
  **Total Project Cost**: $266K (09/87-03/89)
  **Contractor**: Fleet Technology Limited
  **Report:** TP 9647E
  **Project Number**: 6947
  **Project Officer**: P. Semery (514) 283-0030

- **Validation of Ice Resistance Math Models** - This project used a physically segmented model to examine ice resistance on the hull of a vessel to better understand the ship/ice interaction process. A semi-empirical (Rice) and a mathematical model (Carter) predicted loads on portions of an icebreaker and those predictions were compared with the results from the segmentation system, whereby free-floating panels of the hull are instrumented to measure load on the segment. The results indicate that the dynamic breaking pattern influences the mean load on areas aft of the stern. While the total resistance measured on the model appears to be lower than that predicted by the mathematical models, the relative contributors of resistance of the portions of the hull agree with Carter's model. It is recommended that more systematic research on this topic be taken over by IMD for long-term study.

  **Current Yr. PERD Funding:** $173K
  **Total PERD Funding:** $187K
  **Total Project Cost**: $187K (02/88 - 10/89)
  **Contractor**: Fleet Technology Limited
  **Report:** TP 9849E
  **Project Number**: 6994
  **Project Officer**: J. Laframboise (514) 283-0033

- **Ice Blockage of Shrouded Propellers** - Nozzles offer ice-going ships increased thrust and propeller protection, but suffer clogging and blockage with ice. This project was designed to investigate the blockage phenomena and to propose solutions to the blockage problem. Testing was completed using a 1:15 scale model of the Louis St. Laurent equipped with a centreline nozzle. The influence of ship speed, draft, power and other parameters on ice/propeller interaction frequency and blockage frequency was established. Blockage forces are determined as a function of blocking piece geometry, power developed and direction of motion. Water-jets, ice deflectors and various means of minimizing blockage were examined and developed.

**Current Yr. PERD Funding:** $100K
**Total PERD Funding:** $147K
**Total Project Cost**: $234K (09/87-04/89)
**Contractor**: Arctic R&D
**Report:** TP 9640E
**Project Number**: 6948
**Project Officer**: P. Semery (514) 283-0030



*Shrouder propeller configuration investigated*

## Hull Structure

- **Ice Failure Criteria** - This project investigated the mechanisms of ice failure and ice crushing, to better understand structure/ice and ship/ice interaction and predict ice pressures during impact and indentation.

  The first part of the project included a literature review and analysis, and the development of an ice failure prediction model. Indentation (using an "indentor" to simulate ice failure) and impact tests were completed. The interaction of the processes involved in ice microcrack formation and in ejection of pulverized ice was found to be the key to the calculation of pressures in brittle compressive failure. The peak pressure is governed by the damage mechanism in the ice mass, but the time varying pressure is due to the interaction of the damage and ejection processes.

  **Current Yr. PERD Funding:** $70K
  **Total PERD Funding:** $134K
  **Total Project Cost**: $267K (03/86 - 03/89)
  **Contractor**: National Research Council
  **Report:** Final report available October 1989
  **Project Number**: 1101
  **Project Officer**: J.S. McCallum (613) 991-6001

# TRANSPORT OF HAZARDOUS ENERGY COMMODITIES

## Road Transport Safety

- **FRP Tank Testing** - This project developed and tested a new acceptance testing methodology for Fibre Reinforced Plastic (FRP) tanks used in the transportation of petroleum liquids and by-product wastes while subjected to low level pressurization during transfer operations. Acoustic Emission (AE) testing appeared to be the most viable and practical technique. A new software model was adopted to cumulate AE counts, and work on pattern recognition of AE signals was completed. The results show that AE testing can be used to decide whether a tank meets certain safety criteria.

  **Current Yr. PERD Funding:** $14K
  **Total PERD Funding:** $140K
  **Total Project Cost:** $340K (12/85-06/89)
  **Contractor**: Prevost Cartage
  **Report:** TP 9748E
  **Project Number**: 6575
  **Project Officer**: L. Sabounghi (514) 283-0029

# Task 6.6 Transportation of Oil and Gas Ongoing Projects

## NAVIGATION SUPPORT SYSTEMS

### Navigation Information Display

- **STAR-VUE Interactive Assistance** - Arctic shipping requires advanced technology to avoid ice hazards and to locate suitable tracks through ice fields. This project is aimed at acquiring a knowledge base and developing an interactive system to assist the navigator in the interpretation of Synthetic Aperture Radar (SAR) imagery.

  The knowledge base was built from the interpretation of SAR images and the first software prototype design has been completed through consultation with experts from a variety of Arctic shipping operations. This project will provide an image display system, interactive software, and an image database stored on a random access disk. This system will be an asset for training and developing on-line tactical navigational tools.

  **Projected Completion Date**: July 15, 1989
  **Current Yr. PERD Funding:** $184K
  **Forecasted Total PERD Funding:** $204K
  **Forecasted Total Project Cost**: $356K
  **Contractor**: Intera Technology Ltd.
  **Report:** In preparation
  **Project Number**: 6945
  **Project Officer**: M. Audette (514) 283-0044

## HYDROGRAPHY

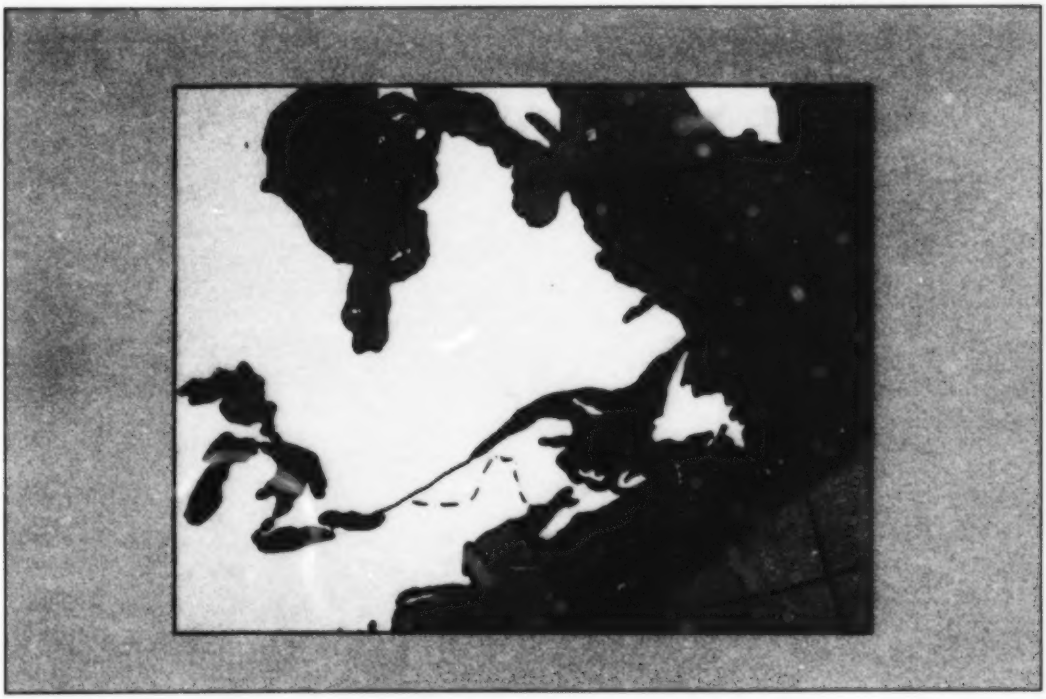
- **Precise Survey Positioning** - Canadian Hydrographic Service (CHS) is using the Global Positioning System (GPS) to provide reliable and cost-effective positioning. When the GPS is fully deployed by 1992, it will enable the CHS to improve the precision, the reliability and the productivity of hydrographic surveys, allowing for complete detection of navigational hazards in harbours and coastal waters.

  The objective of this project was to investigate the effect of the multipath (a signal can travel two or more paths from the transmitter to the receiver) on the GPS. The multipath was found to have little effect on phase observations and its effect on pseudo ranges was minimized by vessel movement. Differential communications testing was carried out to explore the limitations of transmitter differential corrections (corrections to GPS signals observed at monitor stations), using high frequencies. HF (high frequency) testing on the east coast was inconclusive and testing on the west coast will be undertaken.

  **Projected Completion Date**: March 31, 1989
  **Current Yr. PERD Funding:** $40K
  **Forecasted Total PERD Funding:** $40K
  **Forecasted Total Project Cost**: $123K
  **Contractor**: Nortech Surveys
  **Report:** G.P.S. at Sea for Hydrographic Surveying
  **Project Number**: 1033
  **Project Officer**: N.A. Anderson (613) 995-4405

## ATLANTIC OFFSHORE TRANSPORTATION

### Offshore Resource Vessel Requirements



*East Coast Wind and Wave Climate*

- **Wind and Wave Climate Atlas** - The objective of this two-phase project is to summarize and compile wind and wave data for the Great Lakes, the Gulf of St. Lawrence, and the Canadian East Coast. The data will be in the form of an atlas with two volumes. The first volume on the East coast and the St. Lawrence is due at the end of 1989. The second volume on the Great Lakes is due in the middle of 1990. Phase I involved the development of a suitable reference grid covering the above geographical area and recommended the content, format, and database to be used in the preparation of the Atlas. Phase II involves the formatting of the database and the production of the atlas, and is currently underway. A hind-casting process is being used to produce wave information from available wind data. An agreement is being made with the U.S. Army to obtain wave data from their 32 year hind-cast of the Great Lakes.

**Projected Completion Date**: December 31, 1989
**Current Yr. PERD Funding:** $43K
**Forecasted Total PERD Funding:** $122K
**Forecasted Total Project Cost**: $122K
**Contractor**: MacLaren Plansearch
**Report:** None to date
**Project Number**: 6894
**Project Officer**: T. Peirce (514) 283-0078

- **Ship De-Icing Test** - Ship surface ice accretion (icing) affects ship and personnel safety as well as the operability of the vessel itself. In 1986, Melville Shipping Ltd. completed a study on icing exposure to various types of ships and on de-icing and anti-icing tests.

  This project continues research intended to improve the safety and the operability of ships exposed to severe icing. Two ships were tested with surface treatments (ice phobic paints, electrical heat tracing) and equipment (air guns, inflatable de-icers) to investigate the most effective method of minimizing icing. Tests continued during the winter of 1988/89 and results are being analyzed.

  **Projected Completion Date**: June 30, 1989
  **Current Yr. PERD Funding:** $15K
  **Forecasted Total PERD Funding:** $69K
  **Forecasted Total Project Cost**: $122K
  **Contractor**: Melville Shipping Limited
  **Report:** Preliminary final report received
  **Project Number**: 7024
  **Project Officer**: P. Semery (514) 283-0030

## ARCTIC RESOURCE VESSELS

### Arctic Shipping Requirements

- **Eastern Parry Channel Ice Regime Study** - This is a continuing project collecting research to allow for the planning of year-round navigation in the Eastern Parry Channel. Phase I consisted of collection and analysis of a set of synthetic aperture radar (SAR) mapping data of the channel area obtained from a series of aircraft overflights. Phase II will continue the data collection and compare the ice conditions of 1989 with those of 1988, identifying the time period when old ice/first-year ice interaction impedes navigation.

  **Projected Completion Date**: May 30, 1990
  **Current Yr. PERD Funding:** $407K
  **Forecasted Total PERD Funding:** $450K
  **Forecasted Total Project Cost**: $450K
  **Contractor**: Canarctic Shipping Limited
  **Report**: Milestone Report #5
  **Project Number**: 1106
  **Project Officer**: W. Ellwood (613) 990-3087

*M.V. Artic transiting difficult early winter ice conditions in the Eastern Parry Channel*

## Hull Structure Requirements

- **Interaction with Actual Ice Conditions** - The objective of this project is to study ship/ice interaction in real Arctic conditions to advance the prediction of ice loads on all parts of a ship. The current methods for predicting ship/ice loads will be reviewed, and ice features and properties analysed. A theoretical model is being developed for ship/ice interaction and experiments will be conducted to verify and revise the methods developed.

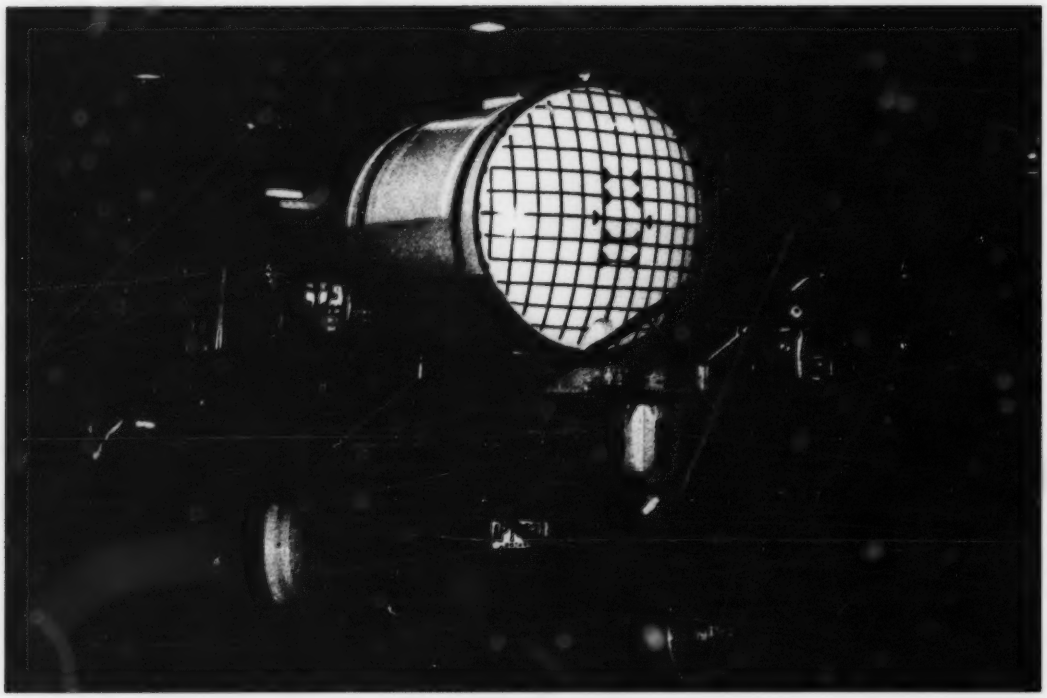
  **Projected Completion Date**: November 30, 1991
  **Current Yr. PERD Funding:** $25K
  **Forecasted Total PERD Funding:** $273K
  **Forecasted Total Project Cost**: $1,612K
  **Contractor**: National Research Council
  **Report**: None to date
  **Project Number**: 1101
  **Project Officer**: J. O'Connor (613) 990-3093

- **Arctic Hullform Optimization** - The objectives of this project are to examine current Arctic tanker hull configurations, and to conceptualize a design optimizing bow, mid-body, stern lines and appendages for a second generation Arctic tanker. The project commenced with an investigation of the current state-of-the-art ship technology combined with the environmental conditions over the route envisaged for this vessel. The conclusions reached led to a particular hullform being identified and optimized using an analytical approach. The results of that first approach optimization were developed into a scale model for tank testing in ice and open water.

  **Projected Completion Date**: October 31, 1989
  **Current Yr. PERD Funding:** $300K
  **Forecasted Total PERD Funding:** $300K
  **Forecasted Total Project Cost**: $466K
  **Contractor**: Canarctic Shipping Limited
  **Report**: In progress
  **Project Number**: TP 7115
  **Project Officer**: T. Peirce (514) 283-0078

## TRANSPORT OF HAZARDOUS ENERGY COMMODITIES

### Road Transport Safety

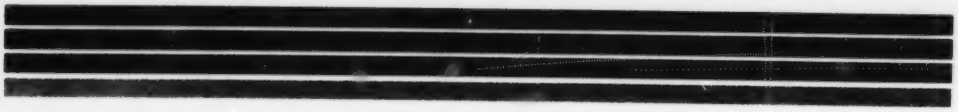


*Liquid tanker test vehicle*

- **Liquid Tanker Stability** - This project involves the development of a computer model to simulate the overturning limits and directional stability of partially-filled liquid tank vehicle combinations. The computer model will be used to evaluate various tank vehicle combinations in view of their weights and dimensions, and to investigate the influence of tank design factors on the directional control and stability performance of general purpose liquid tankers.

  To date, computer models have been developed and are being validated. An instrumented tank vehicle has been fabricated by the Ministry of Transport, Ontario, for the field testing currently being conducted. The validated computer model will then serve as an important design and research tool to develop new configurations of tanks such that the control and stability limits of tank vehicle combinations can be improved.

  **Projected Completion Date**: March 31, 1990
  **Current Yr. PERD Funding:** $35K
  **Forecasted Total PERD Funding:** $288K
  **Forecasted Total Project Cost**: $288K
  **Contractor**: Seshadri Sankar
  **Report:** None to date
  **Project Number**: 6407
  **Project Officer**: L. Sabounghi (514) 283-0029



# FINAL REPORTS

## Energy Efficiency

| TP | TITLE | AUTHOR | DATE |
|---|---|---|---|
| **** | A Study of Logging Truck Fuel Economy Phase III | R. Derek C. Wehefield | Jun 86 |
| **** | An Energy Evaluation of the Nexus Vehicle | R.T. Johnston | May 87 |
| **** | Analysis of the Nexus Vehicle | DAVIS ENGINEERING LTD. | Mar 87 |
| **** | Analysis of the Energy Consumption of a Chrysler T115 Van | DAVIS ENGINEERING LTD. | Mar 87 |
| 8819 | Canadian Railway Motive Power Options and Development Priorities | G.W. English C. Schwier et al.CANADIAN INST.OF GU | Jul 87 |
| **** | Energy Balance Cold Starting and Warm-Up of a Passenger Car | DAVIS ENGINEERING LTD. | Feb 88 |
| 8635 | Energy Efficient Transport Aircraft-Design and Wing Tunnel Test of an Advanced Engine Intake for a Turbo-prop Nacelle Configuration | D.J. Barber I.G. Fejtek DE HAVILLAND | Dec 86 |
| **** | Exhaust Pressure as a Means of Improving the Fuel Economy of Spark Ignition Engines-Phase II | THERMOTECH ENGINEERING | Apr 88 |
| **** | Further Development of On-board Data Acquisition System Prepared for TC Road Safety and Motor Vehicle Regulations | DAVIS ENGINEERING LTD. | Mar 87 |
| 9012E | Nacelle Aerodynamics Research Vol. I Phase I Report | D.Wilford PRATT & WHITNEY DE HAVILLAND | Dec 86 |

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| **** | Technical Memorandum 3 Review of the Canadian Ridesharing Situation | Marot Danard IBI GROUP | Mar 87 |
| **** | Validation of Procedures for Estimating Instantaneous Road Load | DAVIS ENGINEERING LTD. | Mar 89 |
| **** | Fuel Consumption Survey of Cars,Light Trucks, and Vans (April-June 86) | STATISTICS CANADA | Aug 87 |
| 6777 | Logiciel de Simulation des Operations Ferroviaires au Port de Montreal | GIRO INC. | Mar 86 |
| **** | Reduction of the Fuel Economy Penalty Associated with the Operation of Road Vehicles at Low Ambient Temperatures | DAVIS ENGINEERING LTD. | Mar 86 |
| 8140 | Energy Economy Through the Use of Synthetic Oils in the Engine Transmission and Two Rear Axles of Road Transport Vehicles | FERIC | Nov 86 |
| 9276 | Assessment of Advanced Bus Suspension Technology | UTDC | Mar 87 |
| 9202 | Differences Between Laboratory-Tested and On-The-Road Fuel Consumption Rates | SOM | Apr 88 |
| 9778E | $CO_2$ Refrigeration for Long Haul Transport | B. DeLargavant FREIDEV REFRIGERATION SYSTEMS LTD. | Apr 89 |
| 9877E | Passenger Car Fleet Fuel Consumption Estimation Program | David C. Biggs | March 89 |
| **** | Vehicle Coastdown Resistance Analysis Under Windy and Grade-Variable Conditions (SAE 8903071) | B.A.P. Remenda A.E. Krause P.B. Hertz | Mar 89 |

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| **** | The Reduction of City Bus Exhaust Emmissions by Means of a Regenerative Power Train (SAE 890267) | A.S. Davies NRC | Feb 89 |
| 9775E | Bombardier Single Cylinder Medium-Speed Research Engine and Test Facility.Phase IV Development of Lube Oil Evaluation Engine and Turbocharger Rig | M. Payne BOMBARDIER INC. | Apr 89 |
| **** | Further Study of the Feasibility of using the Truck Tire Rolling Resistance Rig for Monitoring Road Roughness Phase I Report | DAVIS ENGINEERING LTD. | Feb 89 |
| **** | A Method of Assisting Cold Starts, Improving Fuel Economy and Reducing Emissions of Engines at Cold Temperatures (SAE 89001) | V.K. Rao M.F. Boudon D.P. Gardiner | Apr 89 |
| 8984E | ALRT Impact Assessment: 87Baseline Travel Survey | D. Peterson R. Glover | Dec. 87 |

## Transportation of Coal

| TP | TITLE | AUTHOR | DATE |
|---|---|---|---|
| 9316E | Rail Transportation of Coal in Western Canada | R.G.Maughan MAUGHAN RAILWAY CONSULTING | May 88 |

## Alternative Transportation Fuels

| TP | TITLE | AUTHOR | DATE |
|---|---|---|---|
| 8307 | Aluminum-Air (Salt Water) Battery for Vehicles | D.S. Strong ALCAN INTERNATIONAL | Apr 87 |

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| **** | Flammability of Vapour Emitted by Methanol/ Gasoline Blends | M.F. Bardon et al. THERMOTECH ENGINEERING | Apr 88 |
| 9470E | Research of Acoustic Emissions in Natural Gas Vehicles Storage Cylinders | CNG FUELS SYSTEMS | Oct 87 |
| 9871E | NRC B-2400 Single Cylinder Research Engine Test Facility: Dynamometer System Upgrade | B.W. Mayes et al. NRC | 89 |
| **** | Development of NGV Cylinder Acoustic Testing Equipment | CNG FUELS SYSTEMS | Oct 87 |
| 9022E | Dual-Fuel Locomotive Program: Project Definition and Preliminary Investigation | M.L. Payne BOMBARDIER INC. | Sept 88 |
| 8765E | The Economics of Natural Gas in Railway Locomotive Applications | INTERNATIONAL RAIL CONSULTANTS | Oct 87 |
| 9519E | Assessment of Saftey of Transportation, Distribution and Storage of Methanol Fuels | R.F. Webb | Sept 88 |

## Transportation of Oil and Gas

| TP | TITLE | AUTHOR | DATE |
|---|---|---|---|
| 8781 | Tank-Car Internal Shell Explosion Suppression System: Preliminary Thermal Feasibilty Study | R.G.Wilkinson A.M. Birk DAVIS ENGINEERING LTD. | Nov 87 |
| 8387 | Arctic Ship Technology The State of the Art - 1986 | MELVILLE SHIPPING LTD. | Mar 87 |
| 9215 | Phase V Final Report, Shipboard Ice Navigation Support System | CANARTIC SHIPPING CO LTD. | Mar 88 |

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| 9063 | M.V.Arctic Vessel Performance and Trafficability Program:Seasonal and Historical Analysis of the MV Arctic Vessel Performance and Trafficability Data Base (83-87) | Pat Gibson NORLAND SCIENCE AND ENGINEERING CANARCTIC SHIPPING CO LTD. | Mar 88 |
| **** | Phase I. Milestone Report #5, Eastern Parry Channel Winter Ice Regime Study | CANARTIC SHIPPING CO LTD. | Mar 89 |
| **** | Ice Crushing by Impact and Indentation, A Literature Review | IAN JORDAAN & ASSOCIATES | Feb 88 |
| 7986 | An Explosion Suppression System for Rail-Tank Cars and Other Containers Holding Pressurized Liquids: Mechanical Design Study | DAVIS ENGINEERING LTD. | Oct 86 |
| 8392 | Development of an Analytical Model of the Hydrodynamic Added Mass of a Ship Ramming Ice | Det Norske VERITAS | Mar 87 |
| 8797 | Investigation of the Added Mass Phenomenon with a Flexible Model of the M.V.Arctic: | ARCTEC CANADA LTD. | Mar 87 |
| | Vol.I-Review of existing methods, available data and summary of experimental results | ARCTEC CANADA LTD. | Mar 87 |
| | Vol.II-Time domain analysis of hull response during ramming | ARCTEC CANADA LTD. | Mar 87 |
| | Vol.III-Model experiments in open water | ARCTEC CANADA LTD. | Mar 87 |
| 8498 | Icebreaking Theory Development by Segmented Model Tests: Refinement of Technique, Vol. II | ARCTEC CANADA LTD. | Mar 87 |

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| 8423 | Tank Thermal Response Analysis: A Study of the Transient Phenomena in a Heated Vessel During Depressurization: Pressure Relief of Partially Filled Horizontal Cylinders Vols I and II. | R.A. Doyle<br>J.E.S. Venard | Dec 87 |
| 9696E | Sinads: Shipboard Integrated Navigation and Display System | OFFSHORE SYSTEMS LTD. | Feb 89 |
| 9906E | Year-Round Accessibility of the Beaufort Sea from the East via the Southern Route of the Northwest Passage Phase I-Ice Climatology and Navigation Assessment | P. deBastiani<br>A.P. Bell<br>CANARCTIC SHIPPING CO LTD. | Jul 89 |
| 9647E | Modelling of Ice Class Shafting and Propeller Systems | Bruce Cowper<br>Arthur Karton<br>FLEET TECHNOLOGY | Jan 89 |
| 9640E | Ice Flow and Blockage Investigation of Shrouded Propellers | Vlodek Laskow<br>ARCTIC RESEARCH AND DEVELOPMENT | Jan 89 |
| 9849E | Modification and Testing of an Ice Breaker to Evaluate Ice Resisitant Mathematical Models | I.F. Glen<br>R. Abdelnour<br>M. Steele | Mar 89 |
| 9748E | Development of Non-Destructive Testing Methods for Proving and Retesting Low Pressure Fibre Reinforced Plastic Highway Tankers | Dr. Hoa<br>P. Ouellette | Feb 89 |
| **** | GPS at Sea for Hydrographic Surveying | M. Casey<br>NORTECH SURVEYS | April 89 |